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WATER SUPPLY AND SEWAGE DISPOSAL AT THE MILITARY AVIATION FIELDS, POSTS, DEPOTS, ETC., IN THE UNITED STATES[1]

By Captain Robert H. Craig

The Department of Military Aeronautics was responsible for the location, design and construction of its aviation fields and other posts from the beginning of the emergency until October, 1917, when this work was turned over to the Construction Division of the Army by order of the Secretary of War. Even after this date, the engineering section of the Department of Military Aeronautics governed in a large measure the design of utilities. Water supply and sewage disposal problems were handled somewhat differently than in the larger national army and national guard camps. The water supply problem was marked by the development of a large proportion of ground water supplies. Sewage treatment was marked by the fact that there was no standard unit adopted by the Department of Military Aeronautics as was done by the Army Cantonment Construction Division in its use of the Doten tank.

Civilian sanitary and civil engineers and architects were selected to design the water and sewage systems and as a result the types of design varied through a wide range.

Number and types of fields. There were established 32 regular flying fields and three balloon schools, in addition to several smaller fields which were in use only a short time. A number of general supply depots, repair depots, and miscellaneous posts were distributed throughout the United States, usually located where shipping facilities were readily accessible and within a fairly short shipping radius of the Flying Fields.

Selection of sites for flying fields. In the selection of sites for aviation fields the following qualifications for the location were considered, stated in the order of their approximate relative importance: (a) topography and soil conditions, (b) climatic conditions, (c) general health conditions, (d) location with respect to transportation facilities, (e) strategic location. This arrangement is somewhat different from that used in the selection of the site of a national army camp, national guard camp, etc., where general health conditions were the first consideration.

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(a) Topography and soil conditions:—Aviation fields, under present flying conditions, must be located in the midst of a flat or almost flat country with a landing field that is nearly level so as to permit of easy rising and landing. The soil must be such that it drains readily and does not become excessively muddy, in order to permit the planes to rise from the ground readily and to prevent landing gear from becoming mired.

(b) Climatic conditions affect the aviation training to a greater degree than the training of infantry, artillery, etc. For the maximum efficiency in the training of aviation students the climate should be fairly warm or moderate, with little or no cold weather. There should be a minimum amount of rainfall, and wind conditions which are not extremely variable or subject to sudden change.

(c) General health conditions should be such that a safe, sufficient and potable supply of water is obtainable with reasonable expense; that sewage, garbage and other refuse can be disposed of with a minimum of cost and nuisance; that mosquitoes, flies and other insect pests are not present in sufficient numbers to interfere with good health or affect the comfort of the men, or where their breeding can be readily controlled; and that communicable disease is not excessively present.

(d) Transportation facilities should be such that food, materials of construction, planes, engines, etc., can be easily shipped to and from the field.

(e) Strategic position of fields in the United States covers such points as inland locations; location with respect to defense of seacoast; proximity to railroad centers, etc. In connection with requirements for the location of fields it is interesting to note their distribution and positions in the United States (table 1).

Expansion of fields in summer of 1918. In order to meet the requirements of the enlarged aviation program of the summer of 1918 it was necessary to increase the size and capacities of some of the water and sewage systems and plants. In general the water supply was adequate to meet the increased needs but some of the sewage treatment plants had to be augmented with new units or an addition to the old ones.

TABLE 1

Location of aviation fields showing their distribution throughout the United States

Southern States

Texas
Barron
Brooks
Call
Carruthers
Ellington
Kelly No. 1
Kelly No. 2
Love
Rich
Taliaferro
John Wise Balloon School

Florida
Carlstrom
Chapman
Dorr

Georgia
Souther

Alabama
Taylor

Mississippi
Payne

Louisiana
Gerstner

Arkansas
Eberts

Tennessee
Park

Oklahoma
Post

Northern States

Michigan
Selfridge

Ohio
Wilbur Wright
McCook

New York
Hazelhurst
Mitchell

Illinois
Chanute
Scott

District of Columbia
Bolling

Virginia
Langley
Lee Hall Balloon School

Far West

California
March
Mather
Rockwell
Arcadia Balloon School

WATER SUPPLY

After the location of the Flying Fields had been decided upon with reference to topography and weather, the water supply was selected with the following governing factors in mind.

Governing factors in selection of aviation water supplies.

(A) Quality of water:—The United States Public Health Service standard for the purity of drinking waters for interstate carriers, which is the standard also adopted by the Medical Department of the army for waters used by the army, was the determining factor insofar as quality for drinking, washing, and bathing purposes was concerned in the selection of water supplies for the aviation fields.

(B) Quantity of water:—Water supplies were selected with a view to furnishing an abundant amount of water under adequate pressure for all the needs of the fields. The wisdom of this selection has been proved by the fact that the flying fields used larger unit quantities than the national army and national guard camps, although the reason for this larger consumption may have been partly due to some preventable causes. At no time were the aviation fields held down to using a fixed or limited quantity of water, this idea being in direct opposition to the policy of the Cantonment Construction Division of the army, which maintained that 55 gallons per capita per day was adequate. Table 2 appended shows the per capita water consumption at the various fields.

(C) Ease and efficiency of obtaining the supply:—

(a) Proximity to municipal or private supply:—Wherever a good municipal supply or a good private supply was available it was utilized, the water being secured by purchase from the municipality or company.

(b) Availability of ground water. Wherever it was possible to secure water from wells by drilling, this plan was adopted. Most of the fields were supplied from wells driven by the Government on the flying fields or in close proximity to them. The general success met with in securing a suitable water from ground water sources by well drilling was marked.

(c) Surface or impounded water supply which could be made suitable by treatment. It was found necessary to construct but one filter plant during the war period (Selfridge Field, Mt. Clemens, Mich.) although one other filtered water supply was developed later (Langley Field, Va.). Table 3 shows the types of supplies utilized.

Development of supplies. (A) Supplies from municipalities or private water companies:—Water purchased for the use of fields from municipalities or private water companies was delivered through lines leading from the nearest adequate sized water main to the camp distribution system. Frequently it was found necessary to raise the pressure in the camp mains by booster pumps installed at the camp, so that an adequate pressure was available for all purposes. Occasionally the water from outside sources was chlorinated at the

TABLE 2

Water consumption, sewage flow, etc., at aviation fields

AVIATION FIELDS	WATER	SEWAGE	PERCENTAGE RATIO OF SEWAGE FLOW TO WATER CONSUMPTION	TYPE OF WATER PIPE	REMARKS
	gals. per cap.	*gals. per cap.*			
Barron	98.0	99.0	101.0	Cast iron	
Bolling				Cast iron	
Brooks	245.0	274.0	108.0	Wood stave	Taken during low population
Call	66.5	66.5	100.0		
Carlstrom	74.0	65.5	84.4	Cast iron	
Carruthers				Wood stave	
Chanute	112.9	98.2	86.9	Cast iron	
Chapman				Cast iron	Ground water near surface
Dorr	65.5	64.0	97.3	Cast iron	
Eberts	142.0	156.0	110.0	Wood stave	
Ellington	125.0	114.0	91.0	Wood and cast iron	
Gerstner	112.0	144.0	128.0	Wood replaced with cast iron	
Hazelhurst				Cast iron	
Kelly No. 1	171.0	215.0	126.0	Wood stave	
Kelly No. 2	90.0	104.0	113.5	Wood stave	
Langley	83.0			Cast iron	
Love	125.0	124.0	99.2	Cast iron	
March	107.7	74.3	69.0	Wood stave	
Mather				Wood stave	
McCook				Cast iron	
Mitchell	42.0	70.0	166.6	Cast iron	High rate of ground water infiltration
Park	91.0	82.0	90.0	Cast iron	
Payne	86.0	69.8	81.0	Cast iron	
Post	66.0	63.0	95.0	Cast iron	
Rich	136.0	115.0	86.0	Cast iron	
Rockwell	101.0			Cast iron	
Scott	194.0	66.6	34.0	Cast iron	
Selfridge	100.0	61.0	60.5	Cast iron and wrought iron	
Souther	152.0	142.0	94.0	Cast iron	
Taliaferro	188.0	186.0	98.9	Cast iron	
Taylor		124.0		Cast iron	
Wilbur Wright	83.0	81.0	97.0	Cast iron	

TABLE 2—*Concluded*

Balloon schools

AVIATION FIELDS	WATER	SEWAGE	PERCENTAGE RATIO OF SEWAGE FLOW TO WATER CONSUMPTION	TYPE OF WATER PIPE	REMARKS
	gals. per cap.	*gals. per cap.*			
Arcadia...........					
Lee Hall..........				Wood stave	
John Wise.........		139.0		Cast iron	

* Some of these flows were taken after the armistice-signing date when camp populations were lower than normal.

camp even though in some instances it had been already chlorinated at the source.

B. Well supplies (government developed):—There is a similarity in the development of the well water supplies due to the governing policy of the building and grounds section of the Department of Military Aeronautics.

General plan of development:—Wells were drilled, cased, the water raised to the ground elevation into wooden storage tanks by airlift pumps, boosted to an elevated steel tank on a 135-foot tower by a centrifugal pump, gasoline engine or electric motor driven, from which tower the water was distributed through cast iron or wooden mains by gravity to the several points of the field. There were various departures at some of the fields, such as the use of centrifugal well pumps, concrete ground elevation storage tanks, direct pumping to the distribution system with the elevated tank acting as an equalizing reservoir, but the general plan outlined above was ordinarily used. The centrifugal pumps were always connected so that they could be made available for fire fighting purposes instantly.

(C) Filtered water supplies (government developed):—The two filtered water supplies developed did not differ from standard mechanical filter plant design. The water was coagulated with aluminum sulphate, sedimentated, filtered through rapid sand gravity filters and chlorinated.

Chlorination. Necessity for chlorination of well supplies:—Table 3 shows the number of well supplies which were reported as showing

TABLE 3

Water supplies at aviation fields, showing type of supply, agency furnishing water, disinfection

FIELD	AGENCY SUPPLYING WATER	TYPE OF SUPPLY	DISINFECTION. CHLORINE CONTROLLED BY	B. COLI IN WELL WATER
		Municipal and private sources		
Bolling	District of Columbia	Filtered river water		
Brooks	San Antonio Water Supply Co.	Deep well		No
Call	Wichita Falls Water Co.	Filtered lake water	Hypochlorite at filter plant. At field manual solution feed	
Chanute	Rantoul Municipal Water Works	Deep well		
Hazelhurst	Garden City Water Co.	Shallow wells		
Langley	Newport News Water Co. Government built own treatment plant after armistice	Impounded and filtered surface water	Manual direct	
Love	City of Dallas and government	Deep well	Manual solution feed for camp well	Yes
Post	City of Lawton, Oklahoma	Impounding lake, small filters at field	Manual direct	Organisms giving all presumptive tests but not confirmed B. coli.
Rich	City of Waco, Texas	Mixed well water and filtered river	Manual solution and manual direct	Yes; in smaller group of wells
Rockwell	Coronado Water Company, Cal.	Deep and shallow well		No

Scott	East St. Louis and Interurban Water Co.	Filtered river	Chlorinated	
Arcadia Balloon School	City of Arcadia	Deep wells		No
Lee Hall Balloon School	Part private owned; part government	Deep wells	Chlorinated	Suspicious organisms
John Wise Balloon School	San Antonio Water Supply Co.	Deep wells		No
		Government		
Barron	Government	Deep well	Manual solution	Yes
Carlstrom	Government	Deep well	Manual solution	Yes
Carruthers	Government	Deep well	Manual solution	
Chapman	Government	Deep well		
Dorr	Government	Deep well	Manual solution	Yes
Eberts	Government	Deep well		Water sometimes cloudy, no B. coli
Ellington	Government	Deep well		
Gerstner	Government	Deep well	Manual solution	Yes
Kelly No. 1	Government	Deep well		
Kelly No. 2	Government	Deep well		B. coli eliminated by repairing casing
March	Government	Deep well		
Mather	Government	Deep well		
Mitchell	Government	Deep well		No
Park	Government	Deep well		No
Payne	Government		Manual solution	
Selfridge	Government	Filtered lake	Manual solution	
Souther	Government	Deep well	Manual solution	High 37.5° Nut. Agar counts but no B. coli
Taliaferro	Government	Deep well	Manual solution	No
Taylor	Government	Deep well		No
Wilbur Wright	Government	Deep well	Chlorinated but later discontinued	

organisms of the B. coli group. In one or two cases this contamination was due to defective well casings. In some of the remaining cases unconfirmed presumptive tests were reported as B. coli, but in most instances B. coli did actually appear. The Aviation Medical and Engineering Departments considered that it was always better to be far on the side of safety by using chlorine than to take time for extended tests and analyses which might prove its use unnecessary.

Liquid chlorine was used in practically all instances where disinfection was thought necessary, except that hypochlorite of lime was used during times of breakdown of the chlorine apparatus or periods of waiting for arrival of chlorine cylinders. Platform beam scales were used in the majority of installations to keep a constant check on the operation of the chlorine apparatus used. The necessity for skilled operation of these chlorine feed machines was apparent and sufficient repair parts were not usually kept on hand, so that when a machine needed repairs it was often necessary to keep it out of service for a month or so before the proper parts arrived.

Responsibility for quality of water. At all the fields the Medical Department is responsible for the health of the troops. The post sanitary inspector was usually detailed by the post surgeon to supervise or inspect the operation of the water system and to guard against any possibility of contamination of the supply. Sanitary engineers from the Sanitary Corps of the army were assigned to duty at some of the fields to advise in the operation of the water supply purification plant systems, sewage treatment plants, methods of mosquito control, etc., and in such cases intelligent operation of plants usually resulted.

Laboratory control. Few of the laboratories at the post hospitals were equipped with complete facilities for conducting bacterial and chemical analysis. As a result the Medical Department laboratories in the several army zones, the Public Health Service laboratories, and municipal and private laboratories were utilized for this purpose. Samples were collected and shipped for analysis infrequently and irregularly and in most cases the samples shipped were not iced and were on the road for one or two days, causing results of analysis that were not a true index of the quality of the water at the time of collecting the sample.

Operation of water systems. In the early history of the development of the water supply systems and sewage treatment systems at the aviation fields and depots, it was the policy of the Aviation Section to have the Government superintendent of construction take over the operation of the systems after they were completed. Later this policy was changed and maintenance officers were appointed at each post by the commanding officer of the post. The duties of this officer included responsibility for the maintenance and operation of the water supply system, sewerage and sewage treatment, electric lighting and heating; also maintenance and repair of roads, pavements and buildings, etc. The maintenance officer reported to the building and grounds section, air service property division of the Department of Military Aeronautics, through military channels. This section ordered needed equipment or materials for changes in construction and dictated general policies in methods of operation. At some fields, as mentioned above, sanitary engineers of the Sanitary Corps, Medical Department, who were assigned to the fields,to advise on the operation of water purification and sewage treatment plants, actually operated these utilities for the Maintenance Departments.

SEWAGE COLLECTION, TREATMENT, AND DISPOSAL

Collecting systems. Every aviation field and balloon school was equipped with a water carriage sanitary sewer system. At no field was there a combined system, although several were equipped with complete storm water systems in addition to the sanitary sewers. The design of sewers and the materials used in their construction did not vary from standard sewer practice.

Grease. The problem of the collection of grease received much attention and gave much trouble. In the original design of the field sewer systems, small cast iron sink traps were used, these being usually augmented by an outside trap, of vitrified clay pipe or cast iron. Because of the large quantities of water used in the camp kitchens together with the high temperatures at which the water was wasted, coupled with the small size and capacity of the traps, little opportunity was afforded for the cooling of the water and the separation of the grease. The result was that most of the grease passed to the sewage treatment plant. In the summer of 1918 large concrete traps similar in design to the type of trap adopted by the Construction Division for the national army and national guard camps were installed for experimental purposes on some of the camp outfall sewer lines leading to the treatment plants. Because of the collection of the floating fecal matter with the grease, these were soon found impracticable. The type of large concrete trap adopted by the Construction Division to collect grease from a row of kitchens is practical and effects a high ratio of grease collection but means must be provided for frequent removal of the organic matter, such as corn, peas, etc., which gathers rapidly at the bottom of the trap. Bacterial decomposition and putrefaction soon set in with their resultant odors if this removal is not accomplished frequently. Grease was disposed of either by burning or by selling it along with the garbage.

Quality of sewage reaching sewage treatment plants. The sewage upon its arrival at the sewage treatment plant is ordinarily a weak, fresh sewage with the suspended matter in an uncomminuted state, and with a grease content relatively high as compared with average municipal sewage but on the average somewhat lower than that of the national army camp sewage. Table 4 shows the chemical analyses of raw sewage at four typical camps.

Quantity of sewage flow. Per capita sewage flows are given in table 2. The per capita flow is much higher than for national army and national guard camps. The hourly ratio varies widely, the highest rates ordinarily occurring between six and nine o'clock in the morning and at the same hours in the evening. From midnight to six in the morning the flow is at a minimum, becoming almost nothing at some of the fields.

Design of sewage treatment plants. It did not appear necessary to provide sewage screens and detritus chambers except where they were to precede the pumping units. Imhoff tanks were installed at 18 of the 30 sewage treatment plants and at the remaining 12 plants septic tanks were put in. Many of the Imhoff tanks were covered with screens which greatly aided in reducing the fly menace. At only one field was the Doten or Construction Division tank installed, at the Arcadia Balloon School, Cal.

In the summer of 1918 the engineering section, supply division of the Department of Military Aeronautics, formulated the following general rules for the design of sewage treatment plants:

Imhoff Tanks. (a) Sedimentation chamber: flow, 87 gallons per capita; flow takes place in 16.5 hours; normal detention period, 2 hours. (b) Sludge digestion chamber: 0.102 cubic yard per person.

Septic tanks. Normal detention period, 8 hours.

Filters. (a) Sand filters: 1200 persons per acre installed. (b) Sprinkling filters: 200,000 gallons per acre per foot effective filter depth. At 87 gallons per capita per day this equals 2300 persons per acre per foot effective filter

TABLE 4

Chemical composition of raw sewage, Imhoff effluent, and sprinkling and sand filter effluent at four aviation fields. Results in parts per million

	KELLY 1 (JANUARY, 1919)			KELLY 2 (FEBRUARY, 1919)			TALIAFERRO (AVERAGE FOR MAY, 1918)			CARLSTROM (JUNE, 1918)	
	Untreated	Imhoff effluent	Sprinkling effluent	Untreated	Imhoff effluent	Sprinkling effluent	Untreated	Imhoff effluent	Intermittent sand filter effluent	Untreated	Imhoff effluent
Total solids	649.0	457.0	439.0	636.0	536.0	564.0				895.0	694.0
Suspended solids	269.0	69.0	38.0	178.0	48.0	48.0	342.0	146.0	58.0	155.0	194.0
Volatile solids										491.0	421.0
Fixed residue										404.0	263.0
Nitrogen as free ammonia	10.0	13.0	3.0	13.0	18.0	9.0	43.0	5.0	2.3	23.8	28.6
Nitrogen as nitrites	0.02	0.03	0.45	trace	0	2.2	0.011	0.003	1.7		
Nitrogen as nitrates	0.2	0.09	9.3	0.5	0.4		0.69	0.31	2.78		
Oxygen consumed*	83.0	47.0	14.0	92.0	55.0	46.0	200.0	133.0	59.0		
R. O. C.	186.0	97.0	21.0	143.0	101.0	14.0					
Ether soluble (acid)	22.5	19.0	2.6	20.0	5.2	5.6	132.0	55.0	10.0	156.4	33.2
Ether soluble (not acid)	22.8	20.0	2.4	15.4	4.8	5.0				125.6	25.2

* Recommended method, "Standard Methods of Water Analysis," A. P. H. A., 1917.

depth. (c) Contact beds: 70,000 gallons per acre per foot effective depth. At 87 gallons per capita per day this equals 800 persons per acre per foot.

Other things being equal, we recommend the adoption of Imhoff tanks and sprinkling filters, with subsequent chlorination if deemed necessary.

Regarding per capita flow: We quote 87 gallons as being the minimum. However, if it is known that the per capita daily flow will be more than this it should be determined as nearly as possible and be made amply large.

Minimum grades for sewers are quoted:

Size of pipe	*Grade in feet per 100*
6 inches	0.6
8 inches	0.4
10 inches	0.3
12 inches	0.22

Imhoff tanks versus septic tanks. At the aviation fields the problem of the relative expense of the Imhoff tank and the Doten septic tank was not seriously considered, with the result that a majority of the plants were equipped with Imhoff tanks. In general the Imhoff tank gave a higher degree of clarification than the plain septic tank and turned out a better digested sludge.

Imhoff tanks embracing the following features gave the best results: (a) Longitudinal flow; (b) but one flowing-through or settling compartment over each sludge digestion chamber; (c) settling compartment with steep sloping sides, not less than 1:1; (d) with sufficient overlap of sides of settling compartment at slots to insure the complete deflection of the rising gas to the gas vents; (e) with retention period in the settling compartment of between 2 and 3.5 hours; (f) with sludge storage capacity sufficient to insure at least 6 months storage; (g) with gas vent area from 20 to 25 per cent of total tank area.

The relative efficiency of deep and shallow sludge digestion compartments was not determined, although shallow tanks with large sludge digestion capacity have operated as satisfactorily as the deeper ones.

Construction of plants. The sewage treatment plants were constructed by private contractors, the contract being let by the Department of Military Aeronautics, which department employed a civilian inspector to check up construction work. In general, construction was of good quality, performed satisfactorily.

Operation of sewage treatment plants. As mentioned in the paragraph on operation of water systems, the maintenance officer was in charge of the utilities, which included sewage treatment plants. The

Engineering Section of the Supply Division sent out to each camp, in the fall of 1918, a set of "Instructions for the Operation of Sewage Disposal Plants at Aviation Schools." This paper included recommendations for the operation of Imhoff tanks, septic tanks, sprinkling or trickling filters, sand filters, contact beds, screens and chlorine dosage apparatus. It also included directions in regard to measurement of sewage flow and methods of sampling and testing sewage.

Instructions of this kind can be given in great detail and will undoubtedly aid in the proper operation of the plant, but the successful operation of any sewage treatment plant will always depend, in the final analysis, on the intelligent care and control of a skilled operator. It may not be necessary to have this skilled operator in immediate control of the plant operation but he must give constant advice and regular attendance. The engineering section commissioned one such man to travel from plant to plant, making recommendations on plant operation and also making chemical and bacterial analyses of the sewage. The territory covered was necessarily limited because of the time required but the many advantages obtained from the use of this man were apparent.

Laboratory control of sewage plant operation was similar to the conditions mentioned with reference to water supply.

RÉSUMÉ

In general, the water furnished to the aviation fields was of an excellent quality, conforming to the standards of bacterial purity of the Treasury Department for interstate carriers. It was potable and not excessively hard. The quantity was abundant and was enough for all the essential needs of the posts in addition to the non-essential needs, such as the sprinkling of roads and lawns, lavish use of water for bathing, etc. This water was furnished under adequate pressure with sufficient reserve equipment for fire pressures.

The necessity for close laboratory control of water supplies and sewage treatment systems is self-evident and axiomatic. The more general use of correct methods of collection, shipping and analyzing samples is essential.

The use of wood stave pipe did not prove generally satisfactory, although in some cases this was due to the use of greater water pressure than the pipe had been designed for, together with the none too careful laying of the pipe.

The use of chlorine was general, for out of the 20 Government-developed water supplies 10 were chlorinated, and 20 of the 30 sewage treatment plants used chlorine for disinfection of the treatment plant effluent. The flow of chlorine gas, where liquid chlorine was used, was regulated in all but three or four cases by manual control machines. It appears to be better practice at a plant with intermittent sewage discharge due to the use of intermittent filtration units to use a manual control chlorinator resulting in overdosing the sewage at times of low flow, rather than to experience the difficulty with an automatic control chlorinator in dosing widely varying rates of flow. The necessity of intelligent supervision and skillful operation of chlorine machines cannot be overemphasized, as chlorine apparatus is by no means fool-proof.

The average per capita sewage flow at the fields was high, resulting in a weak sewage, and the comparatively simple sewer systems resulted in a raw sewage which was fresh and uncomminuted.

Sewage plant effluents were generally of as good a quality as the water of the streams into which they were discharged.

The grease problem was a real one and had not been successfully solved at the time of the signing of the armistice and not much has been accomplished since.

The outstanding feature of aviation water supplies and sewage disposal systems is the need for skilled operators. A skilled intelligent operator, whether he be the plant attendant or an advisory engineer, chemist or operator, who can make occasional inspections, can often obtain excellent operating results from a poorly designed plant and certainly can do so from a well designed one.